

The Total Linear Momentum Vanishes in the Center of Mass Frame

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Exercise:

We show that the total linear momentum vanishes in the center of mass frame.

Solution:

The center of mass frame is defined such that the velocity of the center of mass is zero.

$$\vec{x}_{\text{COM}} = \frac{\sum_i m_i \vec{x}_i}{\sum_i m_i} \implies \dot{\vec{x}}_{\text{COM}} = 0 = \frac{\sum_i m_i \dot{\vec{x}}_i}{\sum_i m_i} \implies$$

$$\sum_i m_i \dot{\vec{x}}_i = \vec{P} = 0.$$